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RILLY, A FOSSIL LAKE

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THE science of paleontology may be as dry as dust or as interesting as a masterpiece of fiction according to the degree to which its devotees grasp its principles and ideals. All are doubtless inspired by the wish to contribute toward the completion of the geologic record and to elucidate the phylogenies of the animal and plant kingdoms. This most exact and painstaking work undoubtedly forms both the foundation and superstructure of the paleontological temple of science, but, until it becomes open to the devotees of the other earth sciences and to the general public, inspiration and achievement are limited to a small circle of the elect and the temple remains without liturgy or ceremonial.

Fossil floras and faunas are not interesting chiefly as medals of creation, but as the objective evidence of the marvelous living and moving life of the sea, earth and air of bygone days. They record the dynamic and epic history of the struggle for existence during countless ages and furnish the data for what Huxley aptly termed retrospective prophecy—the restoration of the past. We desire to know the progressive changes in the continental outlines; when the invasions of the land by the sea occurred; the kinds of life and how they lived; the depths and temperatures of the waters—whether clear or muddy, brackish or fresh; whether the aquatic forms were inhabitants of lakes, streams, lagoons or seas; whether the land animals and plants were those of forested glades, stream banks, plains or sea shores.

Such questions we ask of fossil floras and faunas and while the reliability of the answers depends upon our exact knowledge of both recent and fossil forms of life and their environments, systematic paleontology is only the means toward these ends.

Some sixty miles directly east of Paris on the western border of the Champagne country—the Campi Catalaunici of the ancients—lies the little town of Sézanne, long celebrated in the annals of paleobotany for the marvelous preservation of lower Eocene plants in travertines. These exposures of traver-

tine, notably La Butte-aux-Grottes southwest of the village, early excited the interest of geologists and we find the deposits described[1] as early as 1842. The travertine is of various kinds —sometimes massive, sometimes irregularly laminated and elsewhere porous and full of minute galleries. Langeron[2] and others have shown that while the more massive deposits may be formed by evaporating waters, the most active agents in its formation were colonies of minute freshwater algæ of the families Nostocaceæ, Oscillatoriaceæ and Chlorophyceæ. The metabolism of these algal colonies caused the soluble bicarbonate of calcium to lose its second molecule of carbonic acid, the insoluble neutral carbonate being thus thrown down from solution and deposited. The travertine thus deposited in the interstices of these algal colonies has a porous structure and the abundance of the larvæ of various dipterous insects in such algal mats readily explains the tiny galleries that traverse the travertine and thus lead us to the conclusion that various midges and gnats danced in the sunshine of the Sézanne woods.

Fossil plants were described[3] from these travertines as early as 1842 and Brongniart[4] enumerated a Marchantites and two ferns from this locality. Watelet[5] added an alder, a beech and one or two other species in 1866, but it remained for Saporta[6] to do full justice to the richness of this deposit, his results appearing in 1868. The late Munier-Chalmas, with characteristic painstaking efforts, devoted much time to making wax casts of the flowers, fruits, seeds and insects preserved at Sézanne and his wonderful collection is now at the Sorbonne. So far as I know he published no descriptions of these objects and except for a fine paper on the flowers, fruits and seeds of Sezannella, a genus of Sterculiaceæ, by Viguier[7] in 1908, they remain undescribed. Langeron[8] has published several short papers on the mode of origin of the travertine and on additional

[1] Duval and Meillet, "Coupe des terrains des environs de Sézanne," *Bull. Soc. géol. France*, 1 ser., tome 14, pp. 100–104, 1842.

[2] Langeron, M., *Soc. Hist. Nat. d'Autun*, 1899.

[3] DeWegmann, *Bul. Soc. géol. Fr.*, 1 ser., tome 14, pp. 70–71, 1842.

[4] Brongniart, A., "Tableau," p. 115, 1849.

[5] Watelet, Ad., "Description des plantes fossiles du bassin de Paris," 1866.

[6] Saporta, Gaston de, *Mém. Soc. géol. France*, 2d ser., tome 8, pp. 289–436, pl. 22–36, 1868.

[7] Viguier, R., *Revue gén. Botanique*, tome 20, pp. 6–13, Figs. 1–6, pl. 5, 1908.

[8] Langeron, M., *Bull. Soc. Hist. Nat. Autun*, tome 12, pp. 431–455, 1899; tome 13, pp. 333–370, 1900. *Bull. Mus. d'Hist. Nat.*, Paris, tome 5, pp. 104–106, 1899: *Idem.*, tome 6, pp. 318–320, 1900.

forms of plants, so that the described flora now numbers about 100 species and many more await description.

Sézanne lies near the western limit of the Champagne country, where the somewhat monotonous vineyard clad chalk plain disappears beneath the escarpment of the Tertiary plateau of the Île de France. It is situated in the Department of the Marne which belongs in part to the Archbishopric of Reims, founded in the third century, and partly to the See of Châlons. Reims, the capital city of the Remi and where the kings of France were crowned, is only about 40 miles to the northward. About 30 miles northeast of Sézanne is Châlons, near which 1,466 years ago (A.D. 451) Attila, the most powerful heathen king that ever ruled in Europe gathered together the Huns of the fifth century after reverses on the Loire and was finally defeated by the soldiers of Aëtius and his Gothic allies in what was the last great victory of Imperial Rome and the first great battle of the Marne. The second great battle of the Marne is fresh in our memories and in its decisive results and in the character and ambitions of the contestants it is in many ways comparable to the battle of Châlons.

A small tributary of the Aube rising in the hills that mark the escarpment of the Tertiary plateau and the chalk plain of the Champagne flows to the southeastward by Sézanne.

During the Upper Cretaceous a shallow sea of Atlantic origin invaded the Paris Basin. The prevailing sediments of this sea were earthy limestones commonly known as chalk, and this Upper Cretaceous chalk now outcrops in a broad ring or aureole around Paris, its inner margin lying from 30 to 100 miles distant. The chalk underlies all the later deposits in the center of the Basin. Its characteristic weathering results in the formation of a more or less treeless plains type of country, such as the plains of the Champagne on the east, of Picardy on the north, of upper Normandy, Maine and Touraine on the northwest and west. This chalk country extends from Bourges northeastward past Troyes and Châlons. At Reims it swings to the west past Vervins. At St. Quentin it turns again to the south past Amiens, Beauvais, Rouen, Chartres, Blois and Tours to Châteauroux. This is a country of ancient as well as modern greatness and the very names carry us back through eventful human history to the days of Cæsar's campaigns. The relics found in the valleys of the Somme and the Seine carry us back still farther to the men of the old stone age, some 10,000 years before Cæsar's time, and the fossil shells that we dig out of the chalk and that represent the inhabitants of this Upper Creta-

ceous sea carry us back some three or four millions of years earlier to a time when man was not even a promise and the dinosaurs were the lords of creation. During its maximum extent this Upper Cretaceous sea covered most of France—the only emerged areas being the massifs of the Ardennes, Bretagne, Cantal and Savoie. The Paris Basin was connected with the Mediterranean along the Rhone valley and with the Bay of Biscay across the lower valley of the Loire. Europe was an archipelago at this time, the Scandinavian and Russian shields being the only large and continuous land masses. This Cretaceous sea eventually commenced to shrink and by slow stages nearly all of the Paris Basin emerged from beneath its waters. Not to dwell upon the events of the closing days of the Cretaceous, which is foreign to my present purpose, it may be noted that while the shallow epicontinental seas lingered longer in some regions than in others, as, for example, in Denmark and North Germany, this was a time of littoral and continental deposits.

The length of time during which the land was emerged varies for different localities, and while we have no measure of this interval it must have been very long, judging by the changes in the life that we observe in the earliest Eocene seas. The Cretaceous seas swarmed with specialized cephalopods known as ammonites. Thousands of species are known and not one survives in Eocene times. The changes in the other forms of marine life, while not so spectacular, are equally marked. For example, in the earliest Eocene sea of southeastern North America, known as the Midway sea, we find an entirely different fauna from that found in the Cretaceous beds lying immediately beneath these Eocene deposits. This change in the life of successive deposits in this region is greater than has taken place in all the time that has elapsed between the Midway and the present. Equally great changes mark the earliest Eocene terrestrial faunas and floras. For example, about 350 species of plants are known from the lower Eocene of southeastern North America and not one of these plants has been found in the Upper Cretaceous anywhere. We are in an apparently new world in Eocene times and, if these changes in the life are an accurate measure of the time involved, it would seem that the seas were absent from the present land surface several millions of years and that the continental outline of Europe during this interval foreshadowed its modern outline.

The earliest Eocene sea in the Franco-Belgian Basin is named the Montian sea from deposits of this age around Mons

in Belgium. The Montian sea was limited in its extent and fell far short of reaching south as far as Sézanne. The first well-known Eocene sea in this region whose sediments are mapable over wide areas is named the Thanetian sea (from the Isle of Thanet in the London Basin) or Landenian sea (from Landen east of Bruxelles in Belgium). Between Sézanne and Reims a considerable area is occupied by the marls and limestones of Rilly, named from a little town of that name south of Reims. These are freshwater limestones and marls that were deposited in a large lake or series of ponds, as is indicated by the variety and numbers of shells of pond snails found fossil in these deposits. Nearly fifty different kinds are known and these include some land snails. Some of the genera are *Physa, Valvata, Planorbis, Succinea, Pupa, Helix,* etc., and they are said to resemble modern forms of the Antilles and South America. In the lakes and rivers were fish of various kinds including the curious mud-fishes (*Amia*) and swarms of gar pikes (*Lepidosteus*), both now confined to North America. Turtles of several varieties (*Chelonia, Trionyx, Emys*) were abundant and salamanders have also been found. Crocodiles basked on the banks or hunted in the waters and these included both the Nile type of crocodile and the long-snouted Ganges type or gavial.

The shores were densely wooded with broad-leafed warm-temperature types of trees, and for these the travertines found at the little butte southwest of Sézanne will give us the best picture of the contemporaneous plant life, although a similar glade flora is found near Louvois, in the sandstone of Vervin and in the marls (Heersian) of Gelinden on the road to Liège.

At Sézanne we can almost reconstruct the whole picture. A swift-flowing stream, as shown by its pebbly bed, cascaded from a low chalk escarpment into a damp wooded ravine which opened into the Rilly lake. Mosses (*Fontinalis*) and stoneworts (*Chara*) sheltered the crayfish (*Astacus*). Moisture-loving plants like the two *Marchantites,* and a variety of ferns (*Asplenium, Blechnum, Adiantum,* etc.) covered the stream banks which were overhung by figs and laurels, magnolias, walnuts, maples and a host of tree types since become extinct or no longer found in Europe. Insects and even such delicate objects as flowers are faithfully preserved in the travertine. Among the most interesting of these are those named *Sezannella* by Viguier and shown in the accompanying illustration (Fig. 1). They belong to the tribe Lasiopetaleæ of the tropical family Sterculiaceæ and are related to existing

forms of the American tropics. The illustration shows a flower with two of the petaloid sepals removed, disclosing the large central superior ovary surrounded by the closely appressed stamens opening at the tips of the anthers and each opposite a reduced scale representing the vestigial petals. The second figure shows the five-valved tardily dehiscent capsule or fruit of *Sezannella*, also found abundantly in the travertine. Both are shown natural size.

Altogether twelve species of ferns have been found at Sézanne, and these include several of the tree fern genera *Alsophila* and *Cyatheites*, eloquent witnesses of the humid climate. There are two palm-like forms referred to the genus *Ludoviopsis* from their resemblance to the curious genus *Ludovia* of the tropical South American Cyclanthaceæ. An entirely extinct genus is *Dryophyllum* with four species in the

FIG. 1. RESTORATION OF FLOWER OF SEZANNELLA, WITH TWO OF THE SEPALS REMOVED, AND OF A FRUIT (NATURAL SIZE).

Sézanne woods. *Dryophyllum* was very common along the borders of the lower Eocene sea both in Europe and America, and is considered to represent the ancestral stock from which both the oaks and the chestnuts were derived. Ten different species of laurel have been found at Sézanne and these include a sassafras. The latter was a varied and common type throughout the Northern Hemisphere during Tertiary times, but is now confined to North America, where its single species is one of the very few plants of the great family of laurels (Lauraceæ) that has survived at any great distance from the equatorial region.

The Sézanne flora contained seven aralias, which are mostly American tropical types in modern floras, although common throughout the Holarctic region during the Upper Cretaceous and earlier Tertiary. Magnolia is another Sézanne type that is no longer found in Europe, but is now confined to southeastern

North America and southeastern Asia. There were six species of *Grewiopsis* at Sézanne which Count Saporta compared with existing Brazilian species of *Luhea.* Some of the more familiar Sézanne types were bayberries or swamp myrtle, alders, birches, elms, cottonwoods, maples, willows, sheep berries, buckthorn and cornel. There were two species of *Zizyphus,* a genus which in the existing flora comprises about two score scrambling shrubs or small trees mostly confined to the Indo-malayan tropics, but with a few species in all tropical countries. In the past *Zizyphus* was cosmopolitan, with very many now extinct species. Some distance north of Sézanne are found white seashore sands (*sables blancs siliceux de Rilly*) with the remains of marine molluscs. These are overlain by the *gravier marin de Cernay.* A few of the land animals that roamed in the Sézanne woods have been discovered around Reims in the latter beds and constitute the so-called Cernaysian fauna of the late Victor Lemoine—the oldest known European Eocene vertebrate fauna. The *gravier marin de Cernay* (Cernay is a little town about three miles east of Reims on the western slopes of the Mont-de-Berru) are seashore and river channel gravels containing sharks' teeth and molluscan shells of mixed marine and estuary forms. Scattered bones represent the land animals that were accidentally drowned or whose dead carcasses were swept down the streams into the estuaries and coastal lagoons. These give us a welcome glimpse of the terrestrial animal life of these early times. They comprise small insectivores, lemur like forms, small gnawing marsupials, numerous primitive carnivores and a few primitive hoofed animals—an assemblage much like that found in the Puerco beds of New Mexico and of similar age. Without dwelling at length on this point, enough has been said to suggest that in these earliest Eocene times the plants and animals of the whole Northern Hemisphere or Holarctic region were much alike and were able to migrate freely from Europe and Asia to and from North America. That Holarctica was a single botanical and zoological province during the early Eocene has long been the conclusion of paleobotanists and vertebrate paleontologists. This does not mean that either the floras or faunas were monotonously uniform throughout this vast region. Some of the types of plants and animals became cosmopolitan, others never did. There were always local assemblages of forest, shore and plains forms. The warm glade floras and faunas of the south as at Sézanne or in the strand flora along the expanded Gulf of Mexico were markedly different from the contemporaneous

plains floras and faunas of more arid regions such as was so much of the western United States during the Eocene.

The succession of events along the shores of the expanding and subsequently shrinking Thanetian sea are clearly indicated in the shifting sediments and their contained fossils. This history is too complex in its details for popular presentation. At one point we recognize seashore sands; at another estuary muds, forming lenses of clay; channel or delta sands and grav-

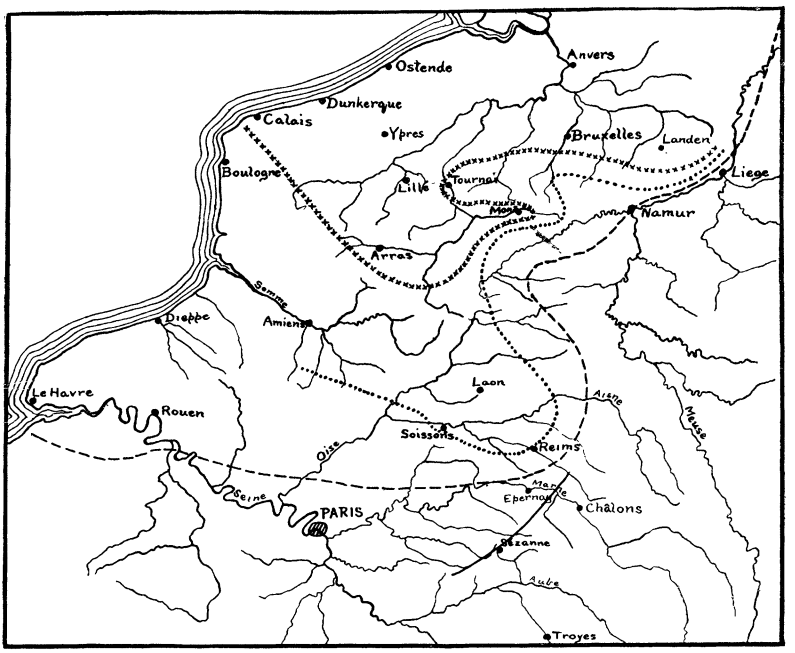

FIG. 2. SKETCH MAP OF A PART OF FRANCO-BELGIAN BASIN SHOWING PROGRESSIVE SUBMERGENCE OF THE LOWER EOCENE.

× × × × × Landward limit of distribution of *Cyprina morrisi* of the early Thanetian sea.

. . . . . Landward limit of distribution of *Pholadomya konicki* of the middle Thanetian sea.

– – – – – Landward limit of distribution of *Cyprina scutellaria* of the later Thanetian sea.

——— Landward limit of the lagoons of the Thanetian sea during its maximum extent.

els occur in places; elsewhere we recognize that we are dealing with beach shingle; lenticular clay beds are seen to represent mud deposits in coastal lagoons; and dune sands are recognizable, as, for example, the *sables d'Ostricourt,* now outcropping from Bethune southeastward to Vervins, and largely made up of fossil sand dunes that followed the retreating strand line, and which contain in places the traces of vegetation appro-

priate to such an environment, as at Artres, Proix and Lewarde.[9]

The accompanying sketch map (Fig. 2), based very largely upon the excellent studies of M. Leriche, illustrates the varying history of the Thanetian sea. The Rilly lake or lakes occupied approximately the area of the rough triangle formed by Sézanne, Châlons and Reims. It is not possible to indicate its outline since its deposits merge in the seashore sands and overlying marine beds that subsequently transgressed it from the north. The sinuous line of small crosses extending from South of Landen and Bruxelles through Tournai and near Mons, Arras and Calais marks the landward limit of distribution of *Cyprina morrisi,* a characteristic mollusc commonly found in the sands of the earliest and most restricted Thanetian sea. As this sea continued gradually to increase in size its shores came to occupy the position of the sinuous dotted line running through Reims and Soissons which marks the landward limit of distribution of glauconitic sands with oyster beds and other marine molluscs and characterized by the species *Pholadomya konicki.* The Thanetian sea continued to grow in size and the somewhat glauconitic but often bleached and consolidated sands of this period in its history, which are characterized by *Cyprina lunulata,* but especially by *Cyprina scutellaria,* mark its maximum limits. The broken line of the map that extends through Liège and Namur, east of Reims, swinging westward near Epernay and continuing westward north of Paris and south of Rouen to the present coast near Le Havre, shows the landward limit of distribution of *Cyprina scutellaria* and consequently the minimum limit of the open Thanetian sea at its maximum stage. These sands (*sables de Bracheux, sables de Châlons sur Vesle*) pass imperceptibly into the non-marine shore sands of Ostricourt. The solid line on the map running northeast and southwest through Sézanne marks the landward limit of the lagoons along the low coast of the Thanetian sea at its maximum stage of water.

The sea did not stay at this height for any long period of time, geologically speaking, and as it slowly withdrew to the northward, we find these sands overlain with the sand of dunes and of successive beaches marking the various stages of its shores during their retreat to the northward. These sands are interspersed with beds of lignite representing a succession of palustrine or marsh deposits that were formed in the bayous

[9] Gosselet, J., " Quelques remarques sur la flore des sables d'Ostricourt," *Ann. Soc. géol. du Nord,* tome 10, pp. 100–106, pl. 5, 1883.

of the sluggish rivers or behind successive barrier beaches, and these lignites are interspersed with the plastic clay deposits so common over a wide area in the Paris Basin recording the finer muds contemporaneous with the sands and lignites and deposited in bayous, estuaries, impounded stream-mouths and coastal lagoons. This series of deposits, which are prevailingly clays and lignites, and which overlie the marine sands of the Thanetian, commenced to form at the south while the marine deposits were still being laid down a slight distance farther north, and they are younger and younger as they followed the gradually diminishing sea in its course to the northward. These clays and lignites contain many representatives of the

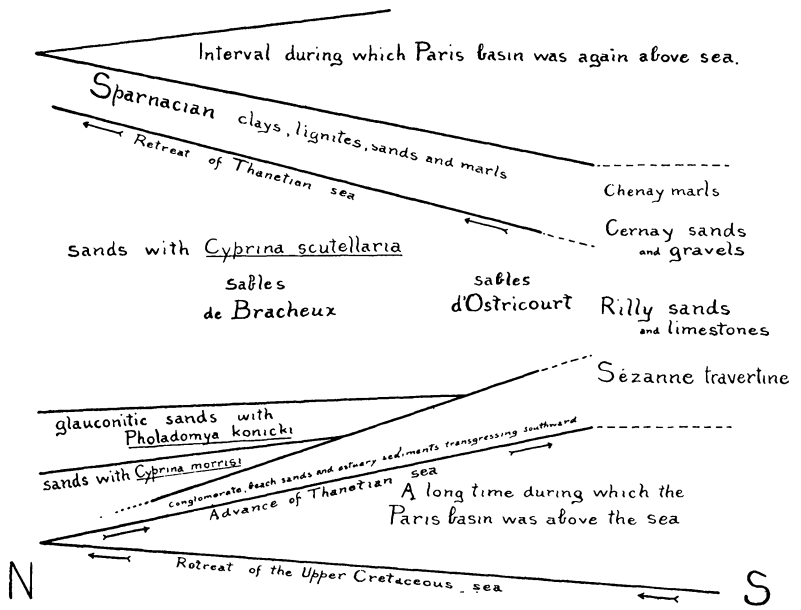

FIG. 3. DIAGRAM SHOWING THE MIGRATION OF THE STRAND, THE STRATIGRAPHIC HISTORY AND THE BLENDING OF MARINE AND CONTINENTAL DEPOSITS DURING THE THANETIAN STAGE OF THE EOCENE.

land animals and plants of the times and because of this fact and the prevailing lithologic character of the deposits, namely, clay and lignite as opposed to the underlying sands, they have usually been segregated as a separate stage under the name Sparnacian, although they really represent the last or prevailingly continental deposits of the Thanetian cycle of submergence. Hence some authors group them as a substage with the Thanetian marine sediments and call the larger unit the Landenian stage. A period of emergence during which the Paris Basin was again dry land followed the Sparnacian.

The geological history thus briefly sketched is represented by the diagram shown in Fig. 3, which summarizes the advance and retreat of the Thanetian sea and shows some of the characteristic deposits accompanying these changes, and their relation to the deposits forming at the same time on the land, in the stream at Sézanne and in the Lake of Rilly. Thus what in the first survey of the areal geologist seemed like an unintelligible tangle of sands, clays, limestones and gravels, becomes resolved into an orderly sequence—of great variability, to be sure—but capable of being separated into its component units, each with its page of physical and organic history.

After the facts have been patiently and accurately accumulated in any area it becomes possible to restore the geographic outline of the continent, the confines of salt and brackish waters, the rivers and lakes, the forests, meadows and swamps, and the life that teemed in all of these environments. The successive shifting scenes can often be more readily deciphered than can we understand the gradual changes that are taking place in our own environment at the present time.